NEAR-FIELD OPTICAL FLYING HEAD

FIELD OF THE INVENTION

The present invention relates to laser disk read-write heads and, more specifically, to a flying head for near field recording.

BACKGROUND OF THE INVENTION

Laser disks including CDs, VCDs, DVDs, MDs, and etc., have been intensively used as data storage medium for the advantages of high capacity, low cost, high portability, and durable use. Following the presence of AV (audio video) multimedia age, the demand for laser disk storage capacity becomes heavier than ever. It is important to increase the storage capacity of a laser disk without changing its dimension.

Various laser disk storage capacity improvement techniques have been developed. FIG. 1 shows a near field recording technique according to the prior art, which reduces the spot size of laser beam emitted by the read-write head to expose (write data into) the laser disk, so as to expose signal groove of thinner line width, increasing the storage capacity of the laser disk. In brief, this method uses a server system to control a flying head **90** to "fly" on the surface of the laser disk **D** at a low elevation (i.e., the near-field distance). The flying head **90** has a semispherical SIL (solid immersion lens) **92** at the front side, and a focusing lens **94** disposed at an inner side and adapted to focus laser beam onto the center area of the

refraction face **96** of the SIL **92**, enabling a small amount of electromagnetic wave (evanescent wave) to penetrate the refraction face **96** and to expose the laser disk in the near field. Because the spot size of laser beam is indirectly proportional to numerical aperture, the high refraction index of the SIL **92** reduces the speed of laser beam, forming 1/n wavelength (because the distance between the refraction face and the laser disk is smaller than λ, light wave does not resume to its original wavelength when passed through the refraction face). Therefore, diffraction limited becomes 1/n of a regular lens, i.e., numerical aperture is increased by n times, and the spot size of light emitted onto the disk is relatively reduced to achieve a thin line width exposure operation.

The aforesaid flying head can produce a laser light spot of spot size smaller than that produced by conventional read-write heads for recording more data on the same size of disk. However, consumers never stop their demand for high capacity of data storage media. Further, fast-developed application products also require high capacity of data storage media. Therefore, there is a strong demand for enabling laser disks to store data in higher density.

SUMMARY OF THE INVENTION

The present invention has been accomplished under the circumstances in view. It is the main object of the present invention

to provide an improved structure of near-field optical flying head, which greatly reduces the spot size of laser beam to achieve a thinner line width near-field exposure, so as to further increase the signal track density and storage capacity of the disk.

To achieve this and other objects of the present invention, the near-field optical flying head comprises a carrier maintained in a near-field distance from the surface of the disk to be recorded; a solid immersion lens installed in one side of the carrier, the solid immersion lens having a refraction face facing the disk to be recorded; and a focusing lens installed in the carrier and spaced from the solid immersion lens at an inner side, adapted to focus a laser beam onto the solid immersion lens, enabling a part of electromagnetic wave to pass through the refraction face and to make a near-field exposure to the disk to be recorded; wherein the solid immersion lens comprises a light scattering layer plated on the refraction face and a dielectric layer plated on the light scattering layer, which causes a chemical reaction to release silver atoms and to enhance electromagnetic wave passing through the refraction face in providing a small optical aperture for the passing of laser beam when received light energy or heat energy. In an alternate form of the invention, the refraction face of the SIL is plated with a mask layer that changes the refraction index to produce an optical aperture in the focused point for the passing of

electromagnetic wave when heated by heat energy of laser beam.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing showing the structure of a near-field optical flying head constructed according to the prior art.

FIG. 2 is a schematic drawing showing the structure of a near-field optical flying head constructed according to a first embodiment of the present invention.

FIG. 3 is a schematic drawing showing the structure of a near-field optical flying head constructed according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 2, a near-field optical flying head **10** is shown comprising a carrier **20**, a SIL (solid immersion lens) **30**, and a focusing lens **40**.

The carrier **20** is an air pad (it is of the known art not the key point of the present invention, therefore it is described in brief hereinafter) controlled by a high-precision server system to fly stably over the surface of the disk **D** within a short distance by means of aerodynamics. The air gap between the carrier **20** and the disk **D** is smaller than the wavelength λ of the laser beam, i.e., the carrier **20** is maintained in the near-field distance.

The SIL **30** is made of glass or material having a high coefficient of refraction and installed in the front side of the carrier **20** near the disk **D**, having a semispherical shape and a refraction face **32** disposed in parallel to the disk **D**.

The focusing lens **40** is installed in the carrier **20** at an inner side and adapted to focus laser beam **L** onto the SIL **30** (the laser beam is emitted from a laser diode through a collimated lens, a polarizing beam-splitter cubic and a quarter wave plate toward the focusing lens **40** in direction perpendicular to the disk **D**).

The aforesaid description is of the known art. The main features of the present invention are outlined hereinafter. The refraction face **32** of the SIL **30** is plated with a light scattering layer **44** by means of evaporation or sputtering, and the outer surface of the light scattering layer **44** is plated with a dielectric layer **46**. The light scattering layer **44** has the chemical property of "been decomposed to release silver atoms when received light energy or heat energy; or reduced to its original compound when light energy or heat energy disappeared". For example, AgOx (silver oxide) can be used for the light scattering layer **44**. When heated, AgOx is decomposed into oxygen and silver atoms. On the contrary, oxygen and silver atoms are reduced to AgOx when heat energy disappeared. The chemical equation is as follows:

$$AgO_x \xrightarrow{+Heat} Ag + x/2O_2 \xrightarrow{-Heat} AgO_x$$

Alternatively, AgX (silver halide) may be used for the light scattering layer **44** in which X of AgX represents F (fluorine), Cl (chlorine), Br (bromine), I (iodine), or At (astatine), i.e., the light scattering layer **44** can be AgF (silver fluoride), AgCl (silver chloride), AgBr (silver bromide), AgI (silver iodide), or AgAt (silver astatide). When heated, AgX is decomposed to release silver atoms. The chemical equation is as follows:

$$AgX \xrightarrow{+h\upsilon} Ag + 1/2X_2 \xrightarrow{-h\upsilon} AgX$$

(in which, $h\upsilon$ represents light energy)

The dielectric layer **46** adopts silicon nitride (Si_3N_4) or zinc sulfide-silicon dioxide ($ZnS\text{-}SiO_2$) to protect the light scattering layer **44**, and to prohibit escaping of gas (oxygen, nitrogen) to the outside during chemical reaction of the light scattering layer **44**. According to the present preferred embodiment, the light scattering layer **44** covers the whole area of the refraction face **32**, and the dielectric layer **46** covers also the whole area of the light scattering layer **44**. Alternatively, both **44** and **46** can cover the center area of the refraction face **32** only, i.e., the laser beam focusing area.

When laser beam **L** passes through the focusing lens **40** toward the SIL **30**, it is focused onto the center of the refraction face **32**, enabling electromagnetic wave to penetrate the refraction face **32**. At this time, the light scattering layer **44** receives the light energy or heat energy of laser beam **L**, and is caused to release silver atoms within a very short reaction time. Silver atoms increase the energy of electromagnetic wave due to the effect of surface plasma, thereby causing an optical aperture to be opened in the focal point for the passing of laser beam **L** to have a relatively smaller spot size of the light at (the internal photoresistance layer of) the disk **D**. Therefore, the invention achieves a thinner line width near-field exposure to increase the signal track density and storage capacity of the disk.

FIG. 3 shows a second embodiment of the present invention. According to this embodiment, the near-field optical flying head **50** is shown comprising a carrier **60**, a SIL (solid immersion lens) **70**, and a focusing lens **80**. The refraction face **72** of the SIL **70** is plated with a mask layer **74**. The outer surface of the mask layer **74** is plated with a silicon nitride dielectric layer **76**. The material of the mask layer **74** can be In (indium), Te (technetium), or Sb (antimony). When laser beam focused onto the refraction face **72** of the SIL **70**, the focused point of the mask layer **74** is fused, causing a refraction index difference between the fused part and non-fused

part of the mask layer **74**, and therefore an optical aperture is opened for the passing of laser beam onto the disk. Because the diameter of the light spot at the disk is so small, minor line width can be exposed to laser beam. Therefore, this embodiment greatly improves the storage capacity of the disk.

A prototype of near-field optical flying head has been constructed with the features of FIGS. 2 and 3. The near-field optical flying head functions smoothly to provide all of the features discussed earlier.

Although particular embodiments of the invention have been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited except as by the appended claims.